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Section 16.1 - Optical Instruments

Institute of Optics

UNIVERSITY OF ROCHESTER

Report on

[illegible]

Contract No. OEMsr - [illegible]

[illegible]

Section 16.1 Report No. 112 Copy No. [illegible]

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Office of Scientific Research and Development

National Defense Research Committee

Section 16.1 - Optical Instruments

Institute of Optics

UNIVERSITY OF ROCHESTER

Report on

WIDE FIELD TELESCOPES

Contract No. OEMsr-160

October 8, 1945

Section 16.1 Report No. 112

OSRD Report No. 6033

Copy No. 26

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of Report on

WIDE FIELD TELESCOPES

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FOREWORD

The Army Air Forces requested in 194[illegible], under Project AC-[illegible]C, that an investigation of night vision devices be carried out by NDRC. Wide field binoculars with large exit pupils seemed likely to prove extremely useful for this purpose. The present report describes several designs for wide field optical systems, including some which employ a modification of the Schmidt straight-in-line erecting system, rather than the usual Porro prisms.

Theodore Dunham, Jr.
Chief, Section 16.1, NDRC
Optical Instruments

[illegible]2-241 Radiation Laboratory
Massachusetts Institute of
Technology
Cambridge 39, Massachusetts
June 7, 1946

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SUMMARY

The need for very compact wide angle telescopes with large exit pupils and high quality optical performance has led to the development of several instruments utilizing modified Porro prisms as well as a slight modification of the erecting system first described by Schmidt. In this erecting system which makes use of two special prisms, the light path is folded upon itself in such a way as to result in a very short instrument with substantially straight through viewing. The usual objection to the Schmidt type of erecting system, namely, bad ghost reflections, has been largely eliminated by the use of non-reflecting coatings on appropriate surfaces. The result has been very satisfactory telescopes of magnification 3X, 6X and 7X with unusually wide [illegible]. In the case of the 7X, the product of field in degrees by magnifica- [illegible] made approximately 85 by the use of one aspheric surface in the eyepiece. This surface is produced by a molding process which has been very much refined by the Institute of Optics and supplied in larg[illegible]duction in other instruments.

The design and performance of the Schmidt erecting telescopes is here described in some deta[illegible] The design and perform[illegible] those systems using modified Porro prisms has been d[illegible]cussed in OSRD Report No. 1482 (Section 16.1, Report No. 23).

[illegible]ial production of the 6 x 42 Porro type instrument in anti-oscillation f[illegible] was undertaken by the Army Air Force. Substantial production of a wide field 7 x 50 binocular for conventional use was undertaken by the Navy Bureau of Aeronautics. The latter instrument was entirely redesigned for production by the Bausch & Lomb Optical Company. This included the return to the conventional non-tapered prism which made the instrument more bulky but facilitated production.

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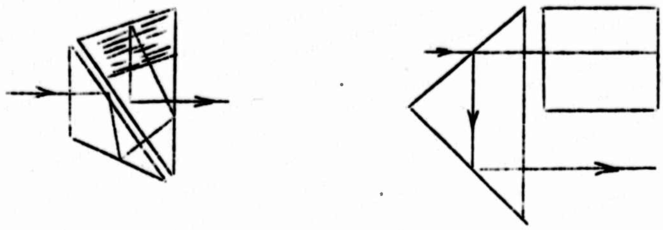
WIDE FIELD TELESCOPES

1. Introduction

Requests for improvements in almost all the figures of merit in prewar telescopes resulted in new designs at The Institute of Optics. Those instruments using the Porro type of erecting system have already been described and will not be treated here except for the addition of Figures 18 & 19, showing the optical assembly of the 7 x 50 binocular and the original 6 x 42. In this report the principal emphasis is on instruments using the Schmidt type of erecting systems. In low power telescopes, the space between the objective and eyepiece becomes very short, and it is difficult to use conventional erecting systems. Also, because of the lack of space, the field must be quite restricted. The Schmidt system, on the other hand, is very compact and can easily be fitted into a low power telescope, having the added advantage that the axes of the eyepiece and objective can be made to coincide, a very desirable feature in a monocular instrument where ease of viewing is important. These systems are also much lighter than those using Porro prisms, and thus easier to carry and use.

Figure 1 is a comparison of the Schmidt erecting system (a) modified by closing the gap between the two prism elements and a Porro system (b) of approximately the same field. It can be seen that the Schmidt system is smaller in every dimension than the Porro and that it deviates the optical axis by only a small amount. The slight offset in the axis is not inherent in the Schmidt system, but is necessary for a prism of minimum size.



(a) Schmidt (b) Porro

Figure 1

II 6 x 42 Monocular

In the spring of 1942, a 6 x 42 telescope with a product of real field (in degrees) by magnification equal to 70 was designed to be used in an anti-oscillation mounted sight described in OSRD Report #1482 (Section 16.1 Report #23). Development of this "night sight" showed the need for a more compact prism system than the modified Porro prisms used there, and accordingly a new 6 x 42 monocular was designed with a Schmidt erector. The same eyepiece was used as in the "night sight" and only slight changes were necessary in the objective design. This new monocular has a real field of view of 11.6 degrees, an eye relief of 19.66 mm and an exit pupil of 7 mm. An Erfle type eyepiece (f' = 25mm) is used, with a cemented doublet of speed f/3.68 as the objective.

The objective was designed to fully correct the spherical and chromatic aberration of the prisms and eyepiece.

At full aperture the total spherical aberration is + 0.032 mm, while at 7/10 aperture it is -0.107. Chromatic aberration is -.00022 at full aperture and is -0.00040 at 7/10 aperture. This correction is as good as it is possible to make with a cemented doublet and glasses now available. Although there is some evidence of axial color when the telescope is used in daylight, due to secondary spectrum and spherical chromatism, the spherical aberration is imperceptible without the aid of an auxiliary telescope. The instrument is chromatically corrected for the C and F rays at 7/10 aperture so that the axial bundle is slightly undercorrected and the marginal rays overcorrected.

Coma is completely corrected by the objective. Lateral color from the eyepiece and prisms cannot be entirely eliminated by the objective, but the residual amount is less than the spherical chromatism of the oblique rays mentioned above. The tangential field of the eyepiece is backward curving and has been matched by that of the objective, but the Petzval fields of the objective and eyepiece curve in opposite directions in the instrument, resulting in a large amount of total field curvature of 4.3 diopters at 30°, most of which (3.5 diopters) is due to the eyepiece. There is no distribution of astigmatism (even with change of eyepiece) that will compensate for the large field curvature, and at the best the resultant image quality of the system has about 2.8 diopters of astigmatism, which is the most objectionable image error in the instrument.

Figure 2 shows the Schmidt prism system made of DF-3 for the 6 x 42 monocular, Figure 3 the objective and Figure 4 the eyepiece specifications. A cut-away assembly drawing of the complete instrument is shown in Figure 5. The original model was made with LF-2 prisms, but if more are to be made, DF-3 is recommended as shown in the drawings.

III 3 x 21 Monocular

A request was received for another monocular with three power magnification and a wide field. Although it used the same eyepiece as the 6X and the same Schmidt erecting system with LF-2 prisms, this three power instrument needed a new objective.

Since the focal length of the objective of a 3X system is half that of a 6X, its field curvature is doubled if a single cemented doublet is used. Thus if a similar objective to that of the 6X telescope were used, the total field curvature would be about 5 diopters, due to the sagittal fields. Redesign of the eyepiece could reduce the tangential field curvature to zero but the sagittal field would be still inward curving by 3.4 diopters and the resulting imagery would show very little improvement. In spite of this very bad curvature, however, a cemented doublet was designed, since it forms a simple and useful instrument for some applications. This is shown in Figure 6. The Image quality is as good on axis and over the equivalent field as any three power of narrower field, with field curvature out to 24 degree half field no worse than the 6 X at the edge.

Field curvature is always a very difficult problem in a telescope, since all known eyepieces give very large curvatures which must be compensated for in the objective. Even if the complete telescope is corrected for curvature, however, the image in the focal plane of the eyepiece and objective is still curved, and parallax with a plane reticle is inevitable. Such an objective has been made at The Institute of Optics, with the realization that if the necessity for eliminating reticle parallax arises, a reticle could be curved or reflexed in through the objective.

Cooke triplets similar to those used in ordinary camera objectives were first tried in the hope that they might improve the field curvature sufficiently but were discarded when the improvement was found to be negligible. It was found, however, that a five element objective could be designed with an over-corrected Petzval radius that would completely cancel the curvature of the eyepiece. Astigmatism of the objective was adjusted to match that of the eyepiece, resulting in an almost completely flat field anastigmatic telescope. At the edge of the field the astigmatism is less than one diopter.

Figure 7 is a plot of the longitudinal spherical aberration curves for the axial bundles in C, D, and F light. Coma in the objective was corrected to practically zero. Lateral color was carefully adjusted to less than 2' for the complete system and is not noticeable in the instrument; there is a slight appearance of color near the edge of the field due to secondary spectrum.

Figure 8 shows results from meter tests on the 3X telescope with the five element objective, demonstrating the remarkably good image quality over the entire field. The blur circle at the edge of the field is actually smaller than in the center, although this is in part due to vignetting. Resolving power tests have not been made with this telescope, but from visual inspection the image quality appears equally good over the entire field. An optical drawing of the objective is shown in Figure 9 and in Figure 10 is shown an assembly drawing of the instrument. It has a real field of view of 23°, eye relief of 20 mm and exit pupil of 7mm.

IV 7 x 35 Monocular with Aspheric Eyepiece

The third monocular designed at The Institute of Optics was a seven power instrument of 5 mm exit pupil and 16 mm eye relief. The product of field by magnification of the whole instrument was 85.4 degrees. For such a wide angle system an eyepiece with spherical surfaces only would either have a large amount of negative distortion or a large zone of positive astigmatism. By making an aspheric curve on the front surface, however, the distortion can be removed without introducting an excessive amount of astigmatism. Such an instrument has been made in Rochester, with the aspheric curve formed by a dropping process described in another report.

In addition to correcting the astigmatism and distortion of spherical eyepieces, the aspheric surface greatly reduces the spherical aberration of the principle rays, so that the eye position remains fixed for the oblique rays as well as the axial rays.

Correction of lateral color is difficult in a wide angle system;

with the 7 x 35 instrument only partial correction was accomplished in the eyepiece and the rest eliminated by a specially designed objective of two separated elements and a special chromatic plate. The Chromatic plate is made of one plano-concave and one plano-convex lens cemented together to act as a single plate of glass for D light but to introduce a large amount of negative axial and lateral color. The separated objective removes the rest of the color and also corrects for spherical aberration. Figure 11 shows the complete design of the system.

V 7 x 50 Monocular with Parabolic Surface in Eyepiece

Before the above 7 x 35 monocular with the thin aspheric corrector plate in the eyepiece was developed, a 7 x 50 monocular with an aspheric eyepiece of a different type was designed. The particular requirements for this telescope were those of a wide field night glass, and thus it was very important to have a long eye relief. In order to obtain the long eye relief, an eyepiece of 25.8 mm focal length was designed, with the curved surface of the eye lens ground to a parabolic shape by the Bausch & Lomb Optical Co.

The rest of the telescope is much the same as the 7 x 35 instrument. The objective is separated and the chromatic plate also used to correct for lateral color. A real field of view of 12.4 degrees, an eye relief of 22 mm and exit pupil diameter of 7 mm are attained in this telescope. The optical system is shown in Figures 12, 13, 14, and 15.

This telescope has been constructed and appears as in Figure 16. The performance is excellent, although the transmitted images appear yellow due to the long [illegible] through the dense flint Schmidt prisms. Since this instrument weighs 2 pounds 10 ounces, considerably more than the 7 x 35, it is now made obsolete by the development of the other monoculer. Also the aspheric in the 7 x 35 is much easier to produce and the mechanical design is much better; if a 7 x 50 were desired in the future it could be made by scaling up the 7 x 35.

VI 3X Monoculer for Lt. Comm. Peckham

In maneuvering pilotless planes, operators have found that they need some magnifying power in order to help them guide the planes at the great distances required. Lt. Comm Peckham, of the Navy Bureau of Medicine and Surgery, requested a light weight low power wide field monoculer to meet this need, which could be strapped to the operators head.

This request was met by scaling down the 3 x 21 monoculer described in section III in the ratio of 1 : 0.771 The resulting instrument has a real field of 23 degrees and eye relief of 15.2 mm and an exit pupil of 5.4 mm; it was not reduced further in size because the eye relief of 15.9 was considered as short as it was practical to use.

The complete design was sent to Dr. Rayton of the Bausch & Lomb Optical Co., for consideration and possibly for the building of a sample instrument.

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Figure 16

7 X 50 Wide-Angle Monocular

The Institute of Optics considered the possibility of inserting an aspheric eyepiece with a focal length of 16.24 mm, which would result in a 3.69 power telescope with the same real field as the 3X telescope. This eyepiece has not, however, yet been designed. Figure 17 is an assembly drawing of the monocular designed for Commander Peckham.

FIGURE 6

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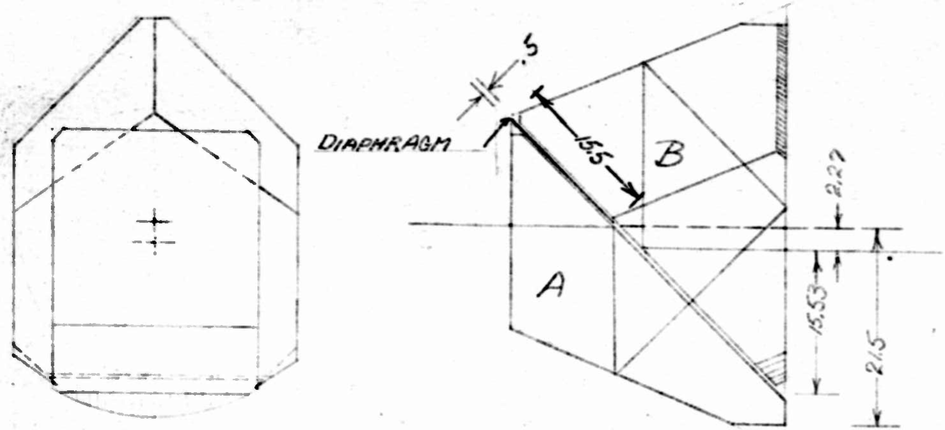
SCHMIDT PRISM SYSTEM
OFFSET OF OPTICAL AXIS 2.27
ENTRANCE APERTURE = 20.4
EXIT APERTURE 29.5



DIMENSIONS MM

INSTITUTE OF OPTICS	
UNIVERSITY OF ROCHESTER	
MAT'L PRISM	FIN.
D'WN BY R.E.H	CH'K ✓
DATE 1/3/44	SCALE 2:1
D'WG No 05321	

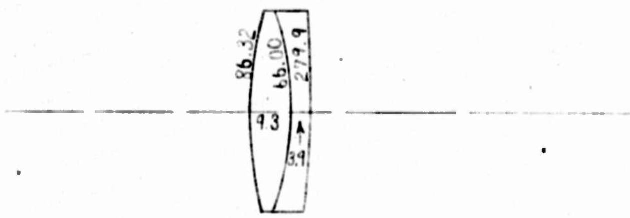
RESTRICTED

FIGURE 2

OBJECTIVE FOR 6X 3X
MONOCULAR - DF-3 PRISMS
PRISM LENGTH = 110.7 MM.

FIG. 3

RESTRICTED



GLASS	N_d	V	t	RADIUS	CLEAR APERTURE	EDGE DIAMETER	
				86.32	42.0	44.0	
C-2	1.5125	60.5	9.3	66.00			
DF-3	1.621	36.2	3.9	279.9			

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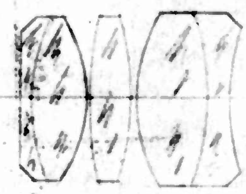
f' = 154.60	D'R'G PERTAINS TO	INSTITUTE OF OPTICS UNIVERSITY OF ROCHESTER	
v' = 147.35		D'W'N BY: R.B.F.	
v = 154.60		DATE: 5/1/44	SCALE: 2:1
E.P. =		D'W'G. NO.: 05251	

EYE PIECE I

FIGURE 4



RESTRICTED

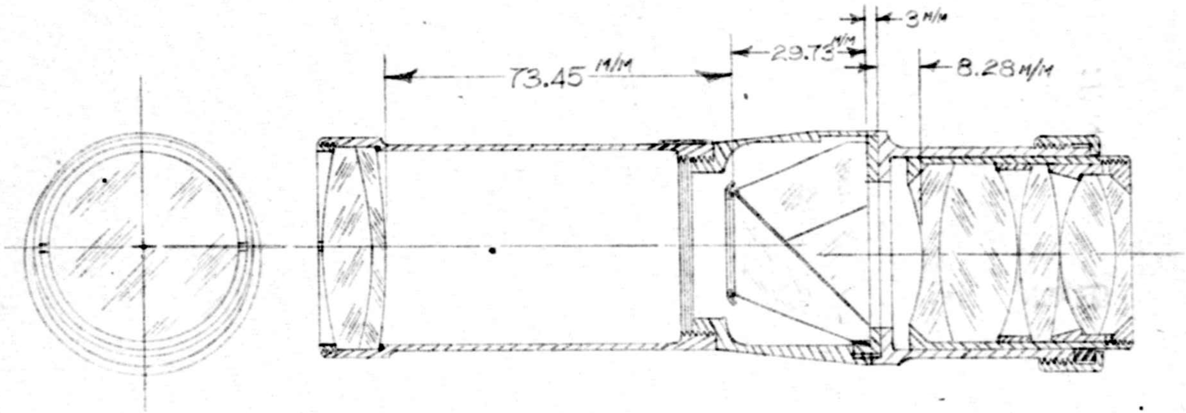
ALL DIMENSIONS IN MM

GLASS	N_d	V	t	EDGE DIAMETER
DF-2	1.617	36.6	2.7	34.8
BSC-2	1.517	64.5	12.9	34.8
			.1	
DBC-2	1.617	55.0	8.7	39.0
			.1	
LBC-1	1.541	59.9	16.3	39.0
DF-3	1.621	36.2	4.7	39.0

RADIUS	CLEAR APERTURE	SAG-EDGE	SAG-CLEAR
∞	26.82		
35.20			
-29.32	33.10		
91.02	38.0		
-71.28	38.0		
36.70	38.00		
-58.99			
48.50	30.86		

f' = 25.9	D'R'G PERTAINS TO:	INSTITUTE OF OPTICS UNIVERSITY OF ROCHESTER
V' = 8.28		D'WN BY: EP · UNIT
V =	RESTRICTED	DATE: 6/22/45 · SCALE: 2:1
EYE POINT		D'W'G No.: 05041
TOLERANCE ON EDGE DIAMETER		

RESTRICTED



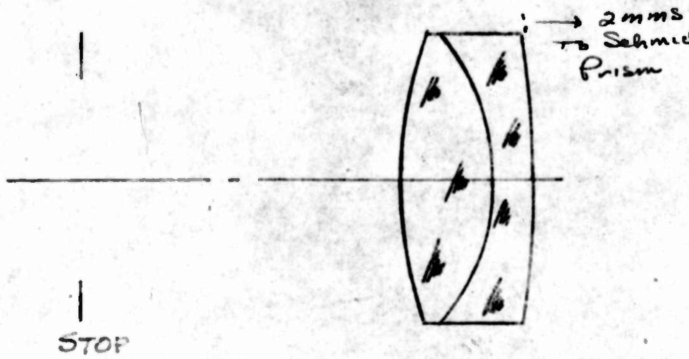
6 x 42 MONOCULAR

FIG. 5

RESTRICTED

3X OBJECTIVE FOR MODIFIED 37$_b$ EYEPIECE

FIGURE 9 6



RESTRICTED

GLASS	N_d	V	t	RADIUS	CLEAR APERTURE	EDGE DIAMETER	
				51.60	22.00		
BSC-2	1.517	64.5	10.00			24.00	
				-24.30			
ELF-1	1.5585	45.5	4.00			24.00	
				-134.90	22.00		

f' = 81.96	D'R'G PERTAINS TO	INSTITUTE OF OPTICS UNIVERSITY OF ROCHESTER
V' =		D'W'N BY: A. PENTA
l' = 74.77		DATE: 2-18-44 SCALE: 1:1
E.P. =	RESTRICTED	D'W'G NO.: 05249

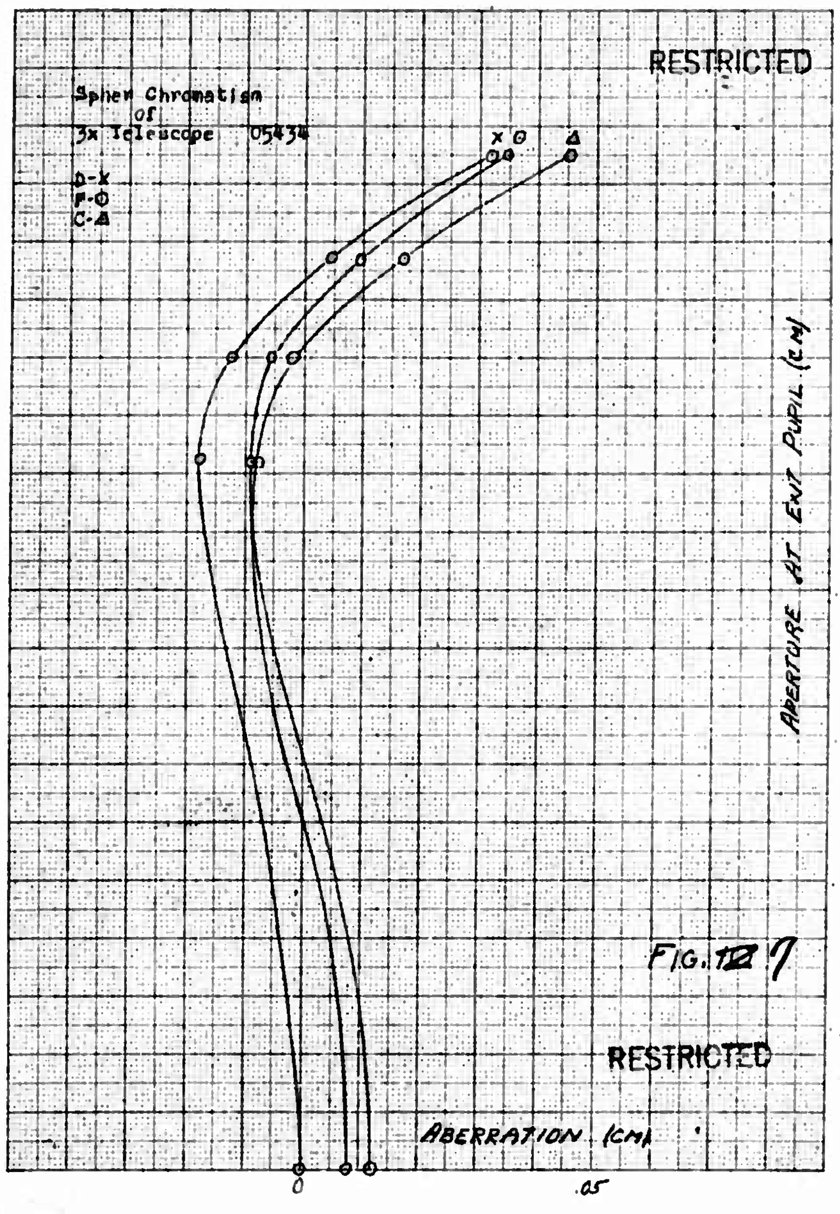

RESTRICTED
Spher Chromatism
of
3x Telescope 05434
D-X
F-Θ
C-Δ
X Θ Δ
.7
6
5
4
3
2
1
APERTURE AT EXIT PUPIL (CM)
FIG. 7
RESTRICTED
ABERRATION (CM)
0
.05

FIG 8 3X TELESCOPE 10-26-44
J.M.

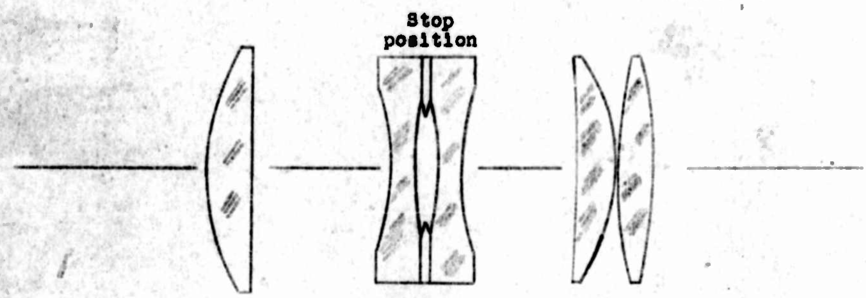
5 ELEMENT OBJECTIVE DRAW NO - 05434 RESTRICTED

RIGHT	APPARENT FIELD	IMAGE	SAGITTAL IMAGE	TANGENTIAL IMAGE	BEST IMAGE	VIGNETTING %
REAL FIELD 0	0	12' 2'	X	X	Same as Image	0
2°	6°20'	11' 2'	X	X	Same as Image	6.5
4°	12°4'	10' 3'	X	X	Same as Image	19.6
6°	17°58'	10'	X	X	8' +.12 D	37.0
8°	23°50	9'	X	X	8' +.12 D	54.4
10°	29°10'	7'	X	X	Same as Image	76.1
10.5	30°40'	6'	X	X	Same as Image	95.7
LEFT						
2	5°45'	12'	X	X	Same as Image	4.4
4°	11°40'	6'	−.12 D	X	Same as Image	15.3
6°	17°32'	7'	−.25 D	+.12 D	Same as Image	30.3
8°	23°3'	5'	−.50 D	+.25 D	4' −.25 D	50
10°	29°5'	5'	−.62 D	+.62 D	4' −.25 D	71.7
11°	31°16'	8'	−.62 D	+1.00 D	6' −.50 D	91.3

Field Limit R 31°15' L 33°20' Av 32°18' RESTRICTED

ANASTIGMATIC 3X OBJECTIVE

RESTRICTED



r	t	GLASS	N_D	V	EDGE DIAM	CLEAR APERTURE
25.71						
	5.00	DBC-2	1.617	55.0	27.0	25.0
	15.25					
- 27.04						
	2.50	EDF-3	1.720	29.3	24.0	14.0
40.00						
	2.50					
- 29.64						
	2.50	EDF-3	1.720	29.3	24.0	14.0
29.64						
	12.70					
-170.00						
	4.40	BSC-2	1.517	64.5	24	22.2
- 21.54						
	.10					
54.08						
	4.0	BSC-2	1.517	64.5	24	22.2
- 54.08						

ALL DIMENSIONS IN MILLIMETERS

EFl = 77.65
BF = 77.97
* STOP DIAMETER = 11.66

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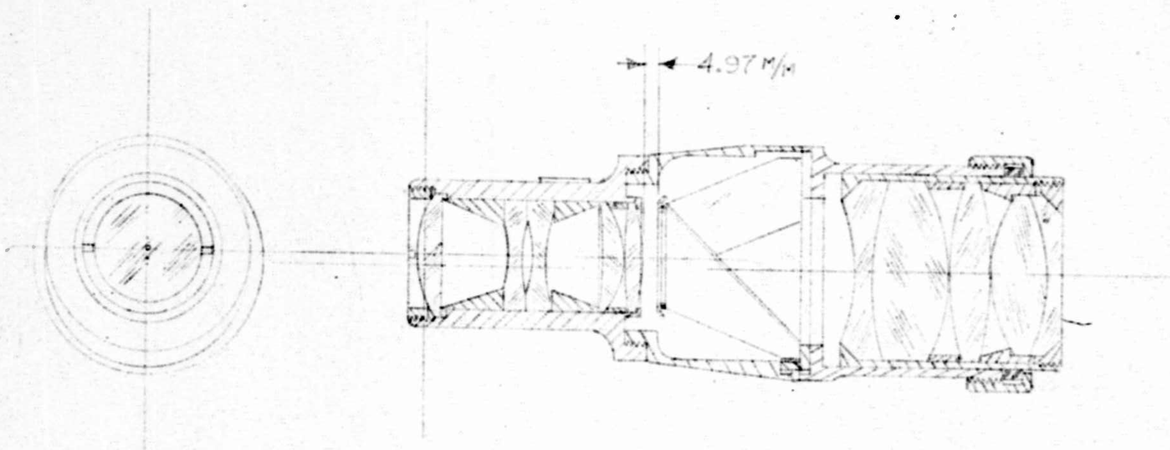
UNIVERSITY OF ROCHESTER
DRWN BY Feder
DATE 2-17-44 SCALE 1/1
DWG NO. 05250

FIG. 9

RESTRICTED

RESTRICTED



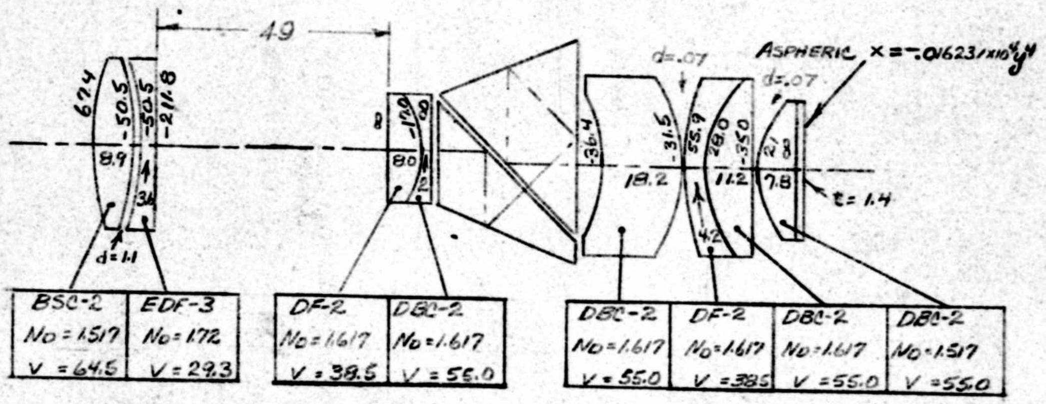
3 × 21 MONOCULAR

FIG. 10

RESTRICTED

RESTRICTED

7x35 WIDE ANGLE TELESCOPE

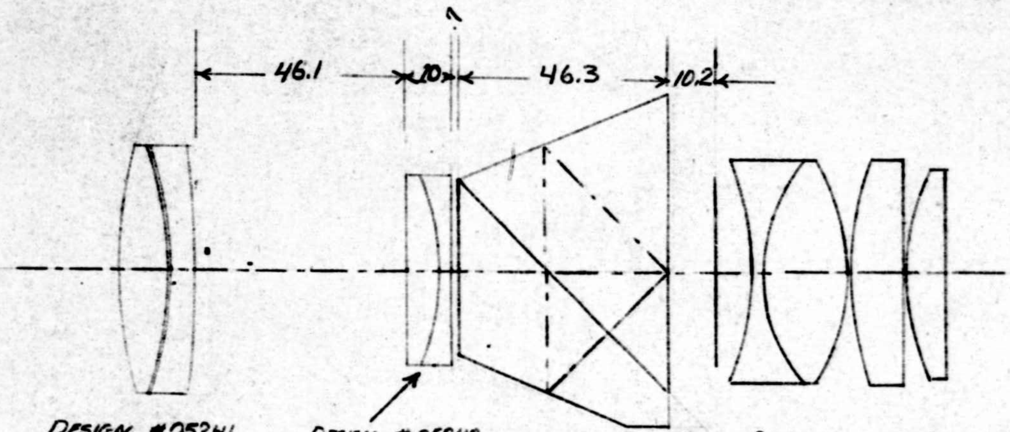


SCHMIDT PRISM SYSTEM
PRISM LENGTH = 110.7
GLASS - DF-2 No - 1.617
DRAWING NO. 05321 (FIG. 2)
FIG. 11

RESTRICTED

7x50 MONOCULAR TELESCOPE

RESTRICTED



FIELD = 6.2° (HALF)
EYE DISTANCE 22 MM
DIA. OBJECTIVE 50MM

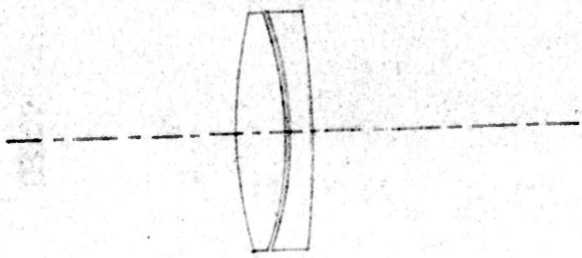
FIG. 12

RESTRICTED

INSTITUTE OF OPTICS UNIVERSITY OF ROCHESTER	
MAT'L MONOCULAR	FIN.
DWN BY R.E.H	CH'K
DATE 1/4/44	SCALE 1:1
DWG NO. 05425	

RESTRICTED

7x50 MONOCULAR OBJECTIVE
$f' = 180$
$V' = 170.5$



R MM	t MM	DIA (CLEAR)	DIA (EDGE)	GLASS	ND	V
101.4						
	11.0	50	55	BSC-2	1.517	64.5
-82.8						
	.7					
-82.8						
	5.0	50	55	EDF-3	1.72	29.3
-248.0						

INSTITUTE OF OPTICS	
UNIVERSITY OF ROCHESTER	
MAT'L OBJECTIVE	FIN.
D'WN BY R.E.H.	CH'K ✓
DATE 1/4/44	SCALE 1:1
D'W'G NO. 05241	

FIG. 13

RESTRICTED

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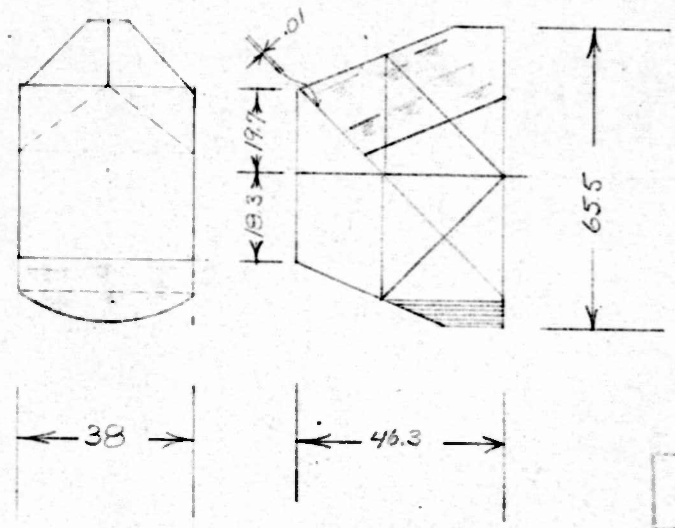
PRISM ASSEMBLY

GLASS No 1.621 V = 36.2



INSTITUTE OF OPTICS UNIVERSITY OF ROCHESTER	
MAT'L PRISM	FIN. ✓
D'W'N BY RE.H	CH'K ✓
DATE 10/5/43	SCALE 1:1
D'W'G NO. 05316	

FIG. 14

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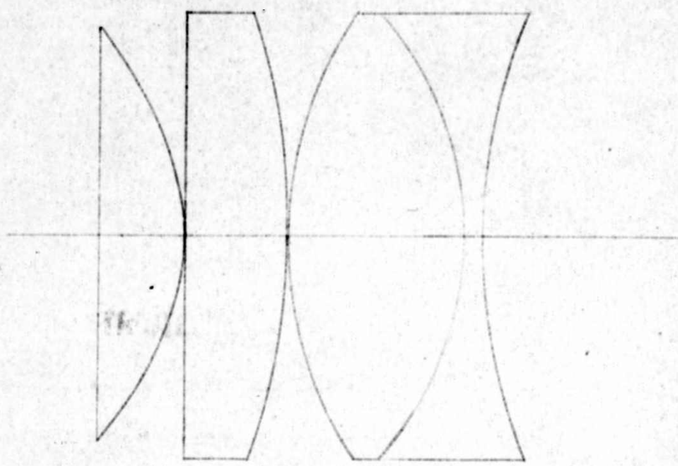
DESIGN H5

$f' = 25.8$ mm.

$v' = 7.98$

Eyepoint with 6X = 22.7



r (mm)	t (mm)	Glass	Diam. (mm)
∞			
	9.34	DBC-3	45.5
+27.57*			
	.1		
∞			
	11.15	Corning 838	48.8
71.5			
	.1		
45.45			
	19.04	Corning 838	48.8
36.32			
	2.0	DF-3	48.8
64.66			

* Radius of a Parabola $y^2 = 55.14X$

FIG. 15

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UNIVERSITY OF ROCHESTER	
MAT'L Asph EyePiece	FIN.
DRWN BY REH	CHK ✓
DATE 6/7/42	SCALE 1:1
DWG NO. 05010	

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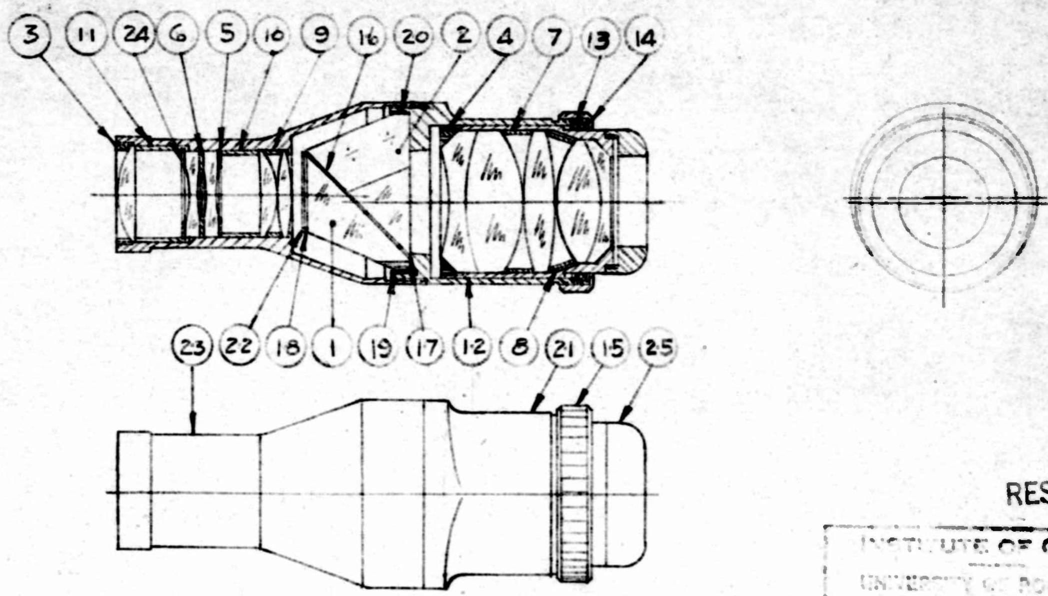

FIG. 17

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DR'N BY A PENTA	
DATE 4-18-45	
D'WG NO. 5211-A-1	

7 x 50 Binocular Telescope
Field of View = 9.8
Eye Distance = 17.6 mm.

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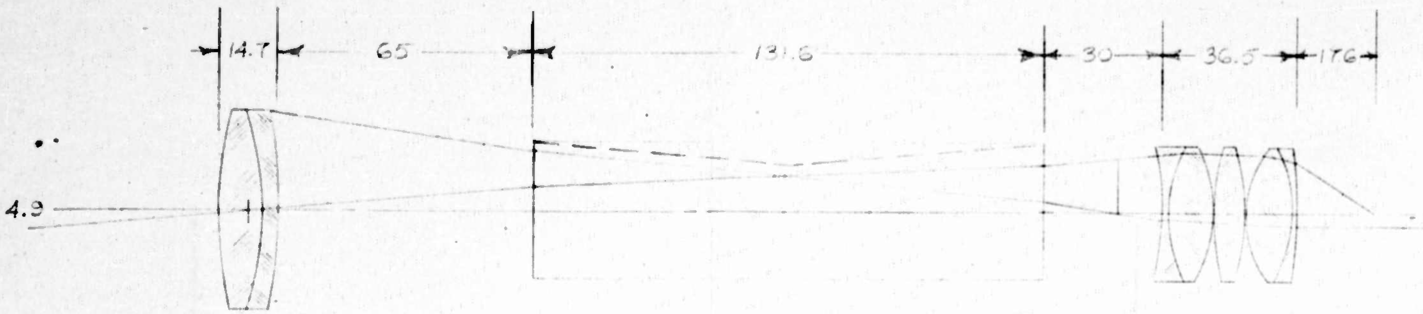

OBJECTIVE

Glass	N_D	R mm	t mm
BSC - 1	1.511	111.1 ± .2	11.7 ± .2
		75.0 ± .2	
EDF - 1	1.649	209.0 ± .2	3.0 ± .2

F' = 172.2 mm
v' = 165.1 mm
Clear Aperture = 50 mm

Drawing # 05202

PRISM

131.6 mm OF LBC-2

N_D = 1.5725
Prism shift of focal plane = 47.91

Drawing # 05300

EYEPIECE

F' = 24.8
v = 9.66

Drawing # 05020

Figure 16

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Drawing # 05417
originally 05200B
0-02-20

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6 x 42 Binocular Telescope
Field of View = 11.6 degrees
Eye Distance = 19.7 mm

OBJECTIVE

GLASS	N_D	R mm	t mm
		84.33	
C-2	1.5125		9.8
		67.6	
EDF-1	1.649		4.2
		254.3	

f'= 150 mm
v'= 143 mm
Clear Aperture = 42 mm
Edge diameter = 42 mm
Drawing # 05211

PRISM

131.6 mm of LBC-2
N_D = 1.5725
Prism Shift of Focal Plane = 47.91 mm
Drawing # 05300

EYEPIECE

f' = 24.8
v = 7.30
Drawing # 05021

Drawing # 05415
Originally 0-11-21

FIGURE 19

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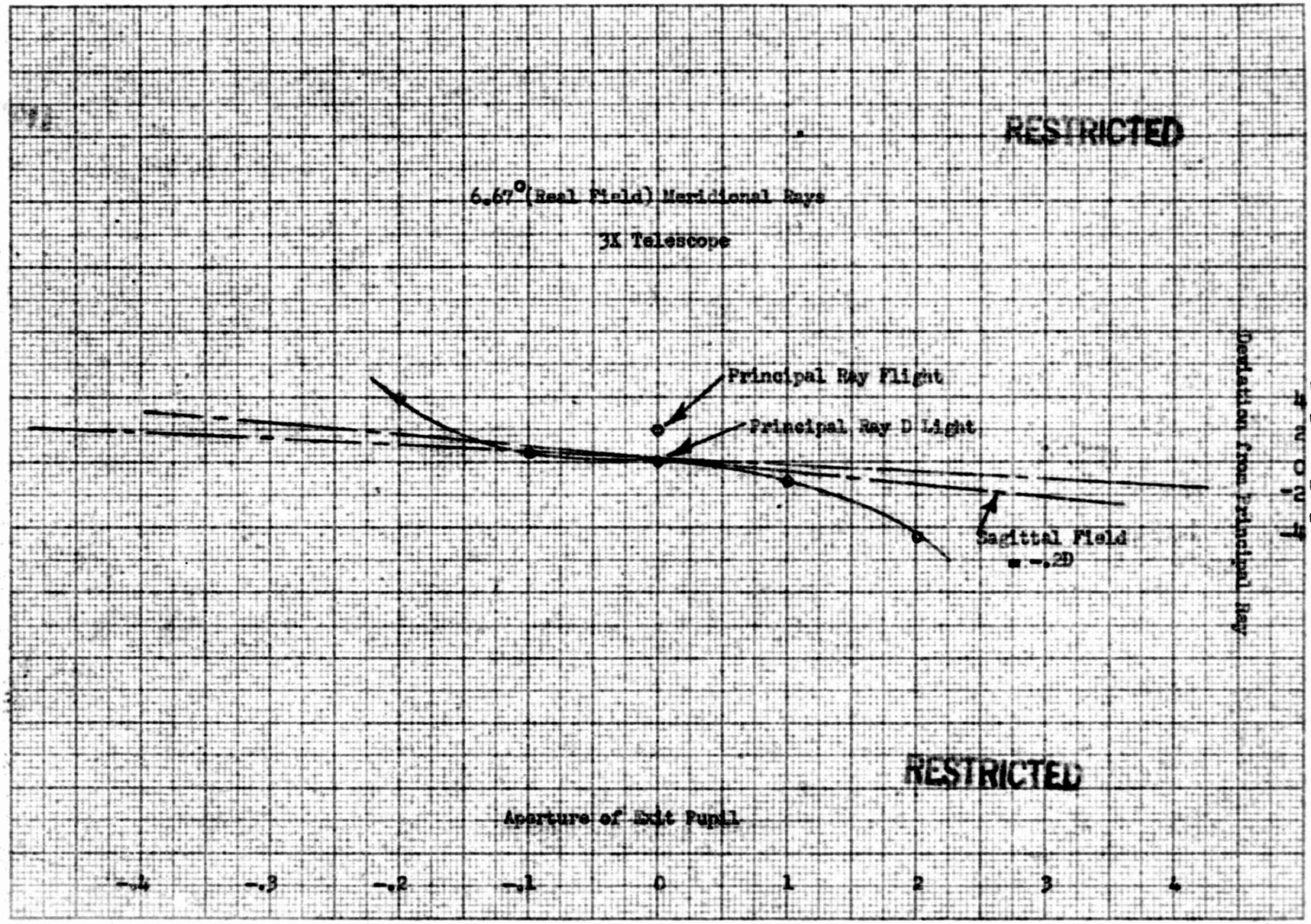
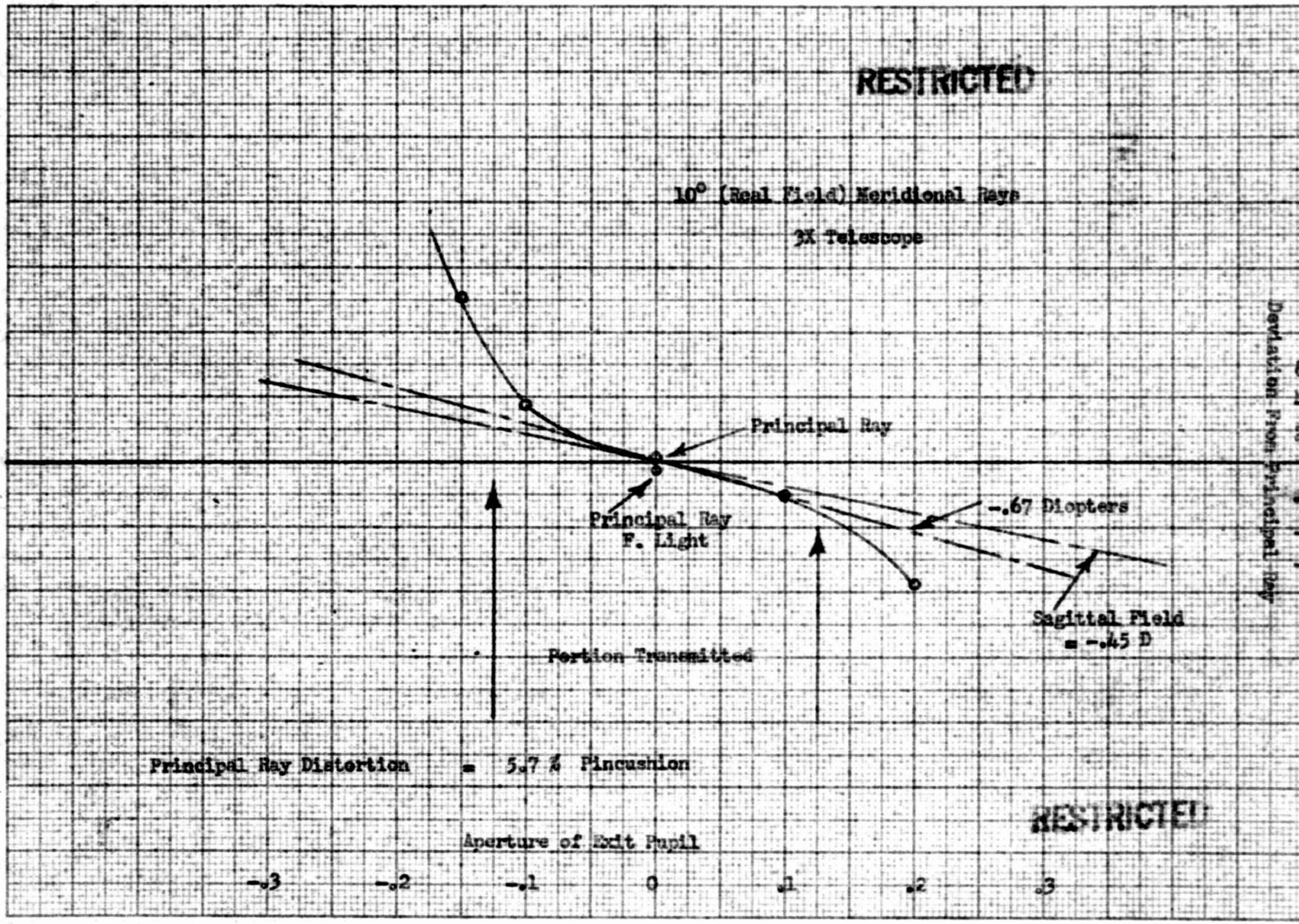
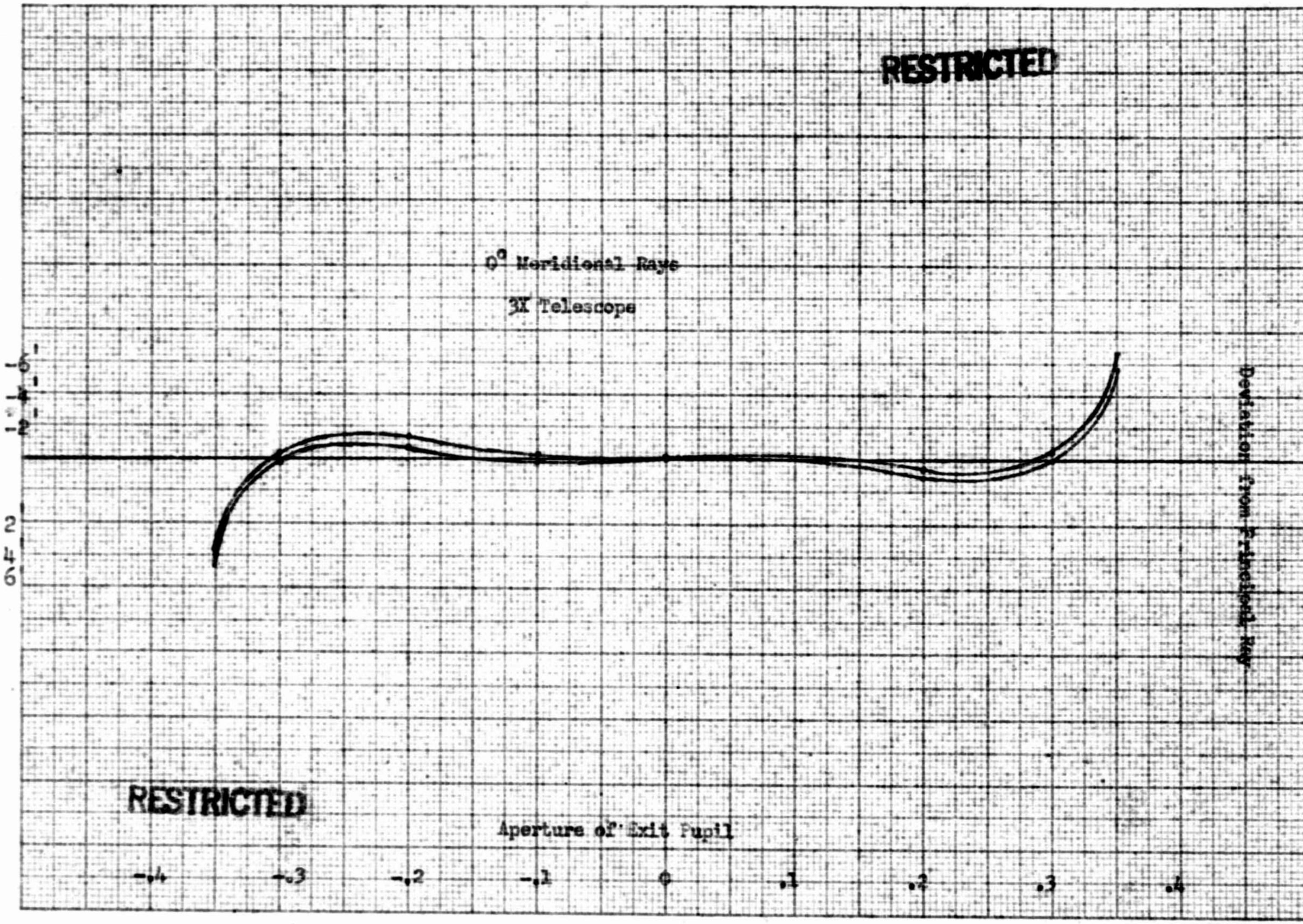
ADDENDUM

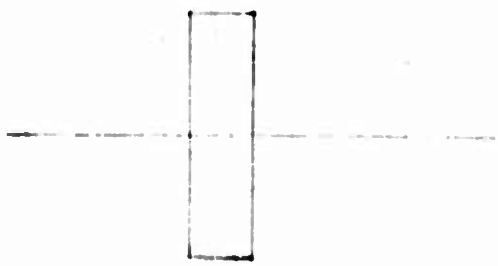
Any dimensions not given in the accompanying figures may be obtained approximately from the scale of the diagram. The thickness of the erector in Figure 2 is 111 mm.


RESTRICTED
6.67° (Real Field) Meridional Rays
3X Telescope
Principal Ray F Light
Principal Ray D Light
Sagittal Field
= -.2D
Deviation from Principal Ray
4
2
0
-2
-4
RESTRICTED
Aperture of Exit Pupil
-.4
-.3
-.2
-.1
0
1
2
3
4


RESTRICTED
10° (Real Field) Meridional Rays
3X Telescope
Deviation From Principal Ray
6'
4'
2'
-2'
-4'
-6'
Principal Ray
Principal Ray
F. Light
-.67 Diopters
Sagittal Field
= -.45 D
Portion Transmitted
Principal Ray Distortion = 5.7 % Pincushion
RESTRICTED
Aperture of Exit Pupil
-.3
-.2
-.1
0
.1
.2
.3


RESTRICTED
0° Meridional Rays
3X Telescope
Deviation from Principal Ray
-6'
-4'
-2'
0
2
4
6
4'
2'
-2'
-4'
RESTRICTED
Aperture of Exit Pupil
-.4
-.3
-.2
-.1
0
.1
.2
.3
.4

[illegible] PLATE
7X50 MONOCULAR 05425



RAD.	THK	DIA	[illegible]	[illegible]	N_D	[illegible]
(x)						
	7.	40	41.38	DF-2	1.617	36.6
-55						
	3.	40	41.38	[illegible]-2	[illegible]	.550
∞						

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MAT'L OBJECTIVE	FIN.
DWN BY R.E.H	CHK'D
DATE 1/7/44	SCALE
DWG No. 05242	

REEL – C
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A.T.I.

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ABSTRACT

Description is given of several designs of wide field binoculars with large exit pupils to aid in night vision. Devices include some which employ a modification of the Schmidt straight-in-line erecting system, rather than the usual Perro prisms. Design and performance of the Schmidt erecting telescope is described in detail. As a result of investigations, very satisfactory telescopes of magnification 3X, 6X, and 7X with unusually wide fields have been developed.

20 Jan 21 Feb 47 39

UNCLASSIFIED per Authority of OSRD List #39, dated
20 January-21 February 1947